AN ON-LINE SYSTEM FOR IMMEDIATE BRAILLE PRESENTATION OF COMPUTER-STORED INFORMATION TO THE BLIND

by

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The ever-increasing use of automated data processing facilities at all levels of business operation makes it necessary for an individual who wants to operate in these areas to be capable of bi-directional communication with such data systems. This presents particular problems to the blind: while they are quite capable of uni-directional communication with existing data systems through keyboards and other standard input devices, the blind can, at present, receive output only in cumbersome and frequently ineffective ways. Effectiveness of the blind in these environments is hampered by the inability to accept standard output such as teletypewriter output, printed listings, and character displays.

In the last several years, a number of attempts have been made to facilitate output for the blind. These attempts have taken the form of braille computer listings, embossed tape, devices to read standard print, etc. Each of these methods provides some capability for the blind. However, each has drawbacks and none exhibits the speed and selectivity required by an efficient data system user. Their availability is generally limited by the requirement that an employer provide modifications of his system to accommodate blind users and, furthermore, where speed is essential, the blind person's limited ability to scan or skim over a mass of data is not helped in the output approaches mentioned.

One of the devices which are employed in computer-based data systems at a rapidly increasing rate is the video terminal. This device communicates bi-directionally with a computer system by direct connection or via telephone lines. Input facility is provided generally by a standard keyboard plus various control keys. Output is provided by a cathode ray tube which displays alphanumeric information. This device permits the user to rapidly and selectively inspect large quantities of data as well as modify, delete or add to the computer files. Many corresponding jobs require no uncommon or highly developed skills and the bulk of computer related jobs in the business sector are in this category, that is, they can be mastered relatively easily if one can use a video terminal. Thus, to open up employment opportunities for the blind, it would be highly desirable to provide employers with a device which can be easily substituted for a video terminal, and at the same time, has an output mode suited for a blind operator.

To date, no one has solved the problem to provide such a terminal environment. More specifically, no one has offered to the blind a braille substitute for the cathode ray tube. In the general case, at first inspection, the problem appears merely to be one of substitution. If, for instance, the display had 20 rows of 72 characters each, the requirement is to merely provide 20 rows of 72 character braille transducers. At closer inspection, this direct substitution appears neither desirable nor technically feasible.

First, at normal braille cell spacing (approximately 1/4 inch) each line would be eighteen inches long without any provision for escape characters. With the required escape characters, the lines could easily be 20 inches long giving a minimum 20-inch by 8-inch area. One doubts the utilization of such an area for long periods without excessive arm fatigue. Secondly, the provision of such a braille array at normal cell spacing utilizing solenoids or similar electromechanical devices is at best a nightmare. Similar problems exist to some degree with a parallel (printer type) embosser. Third, and most importantly, one must consider the difference in information assimilation technique between the sighted and the blind. For the blind, the normal sighted eye-scan cannot be duplicated. Information must be assimilated almost strictly serially because of the characteristics of tactual sensors. This means that the presence of, say, an entire page of information ceases to be an advantage. Therefore, textual information presented to the blind must be augmented by nontextual information in the form of grouping and indexing so that the tactile equivalent of the sighted scan may be performed. Fortunately, the information required in the performance of moderately skilled jobs (e.g., order taking, information service, etc.) typically resides already in the machine in correspondingly organized form; the twofold problem is, therefore, essentially reduced to the single one of providing a suitable output and control set.

The most promising approach appears to be a serial output device, with appropriately high speed capability and with sufficient control to permit the operator wide latitude in the selection of information. A device which appears to have these characteristics is the Argonne Braille Machine display mechanism.

From: Proceedings 1972 Carnahan Conference on Electronic Prosthetics, John S. Jackson and R. William DeVore, eds. Carnahan House. U. of Kentucky, Lexington, Kentucky, Dec. 1972

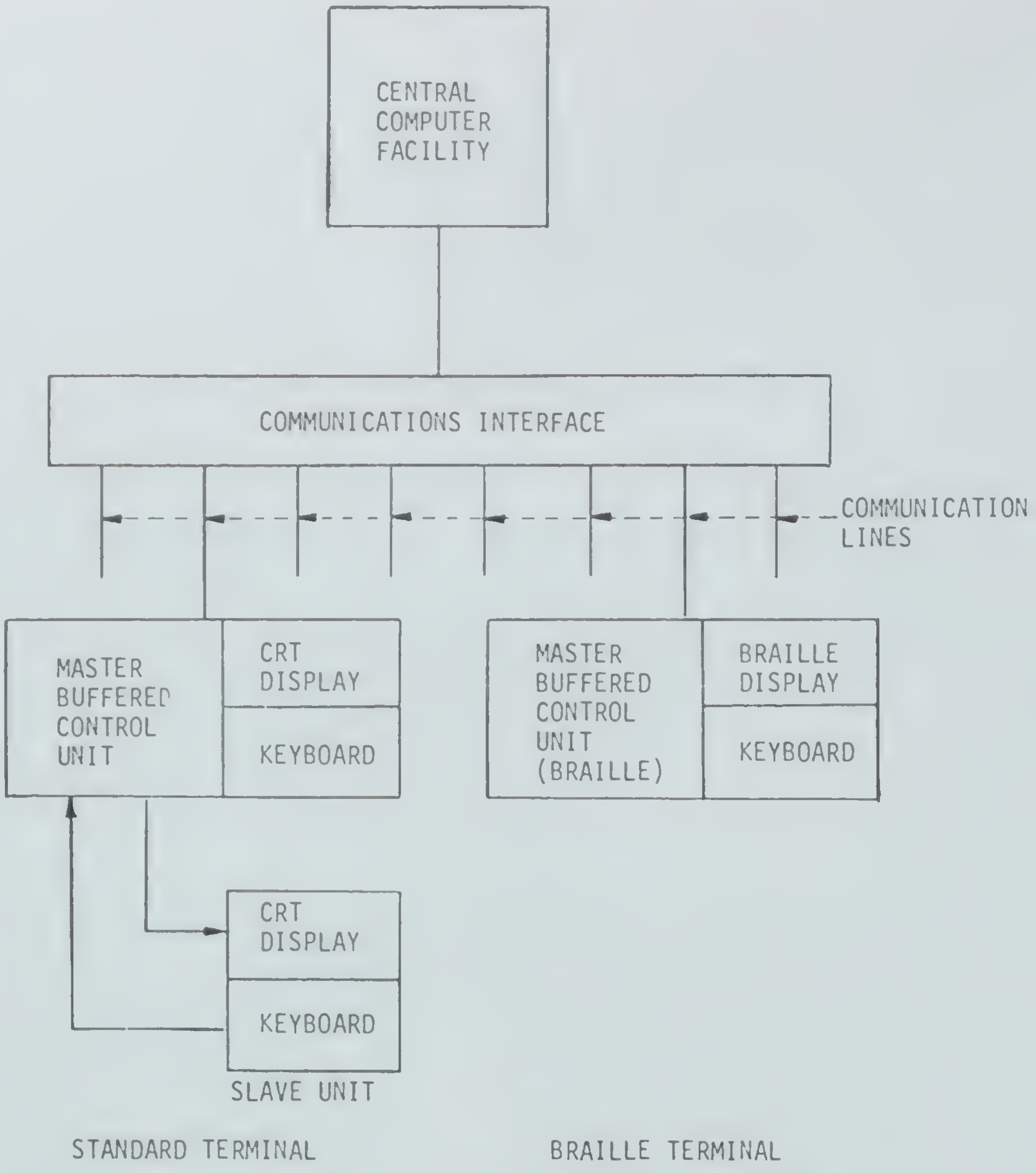


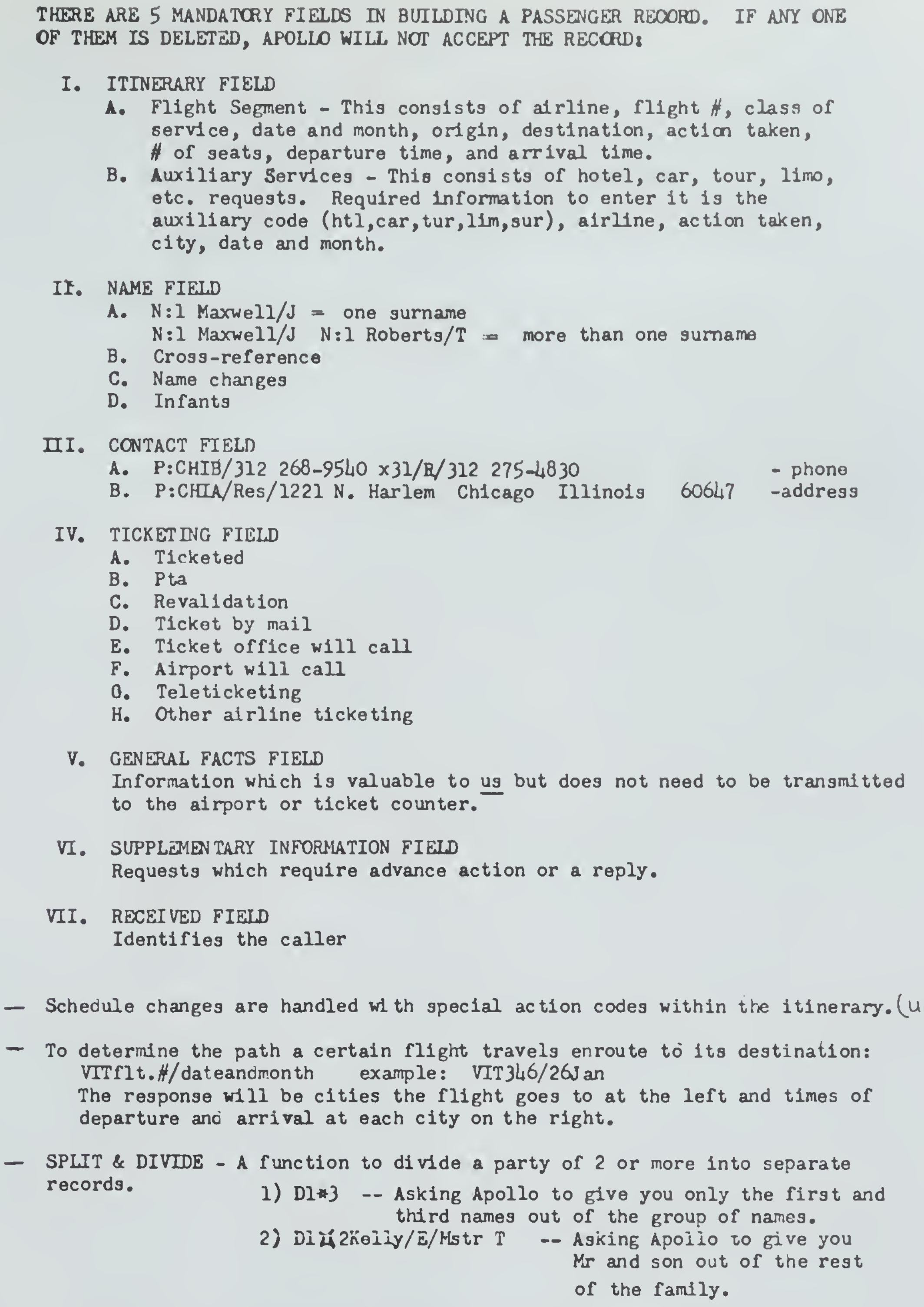
FIGURE 1. Block diagram of a facility with an embedded braille terminal.

This Argonne Braille Machine is really one part of a fairly extensive system which has several far reaching aspects. What concerns us here is the braille display mechanism used in this machine.

Obviously, there is only a limited number of modes or ways of how one can display braille. One such mode may be called stationary, another one dynamic, which means a stationary display would be one (like a page of braille on a table) which is there for the reader to do something with. On the other hand, a dynamic display would be, for instance, a set of characters moving under the reader's fingertips where the person just watches what is going on. There are other basic modes one can think of; let's take a line as an element. It can be displayed in full length and after it has been read, it is removed and the next one appears, or you could move normal to the reading surface to present and remove characters formed, for instance, by rising and falling pins. Conversely you could have, as the principal mode of a dynamic display, a line which is endless and just moves from right to left through a window, so that the sensation, if you hold your fingers to the window, is essentially the same as if you sweep the line on a stationary display with your fingers.

We do not propose to go into all the combinations and permutations here. But we did try to explore possible modes somewhat systematically. For this purpose, we built a device which allows to move a sheet of paper with embossed characters in different modes stepwise up, continually up, sideways stepping and continually, in various increments and with adjustable speed. The only mode that people couldn't read at all was several lines available at a time and kept in a steady upward motion so that one has a relatively large set of characters at any one time accessible. But, as mentioned, this mode does not work. The sweep by the user's hand from left to right and the movement of the characters set from the bottom up left the user with no fixed reference; and he kept losing his place. Conversely, tests with a line moving constantly from right to left with adjustable speed seemed, from the standpoint of the reader, the most favorable ones and it turned out from an engineering standpoint also preferable to anything else; maybe it's just because we know how to do it or that we found out how to do it, but we think there is a systematic advantage in this mode.

We then designed a machine which contains a plastic belt which runs over a platen and recirculates around two



THERE ARE 5 MANDATORY FIELDS IN BUILDING A PASSENGER RECORD. IF ANY ONE OF THEM IS DELETED, APOLLO WILL NOT ACCEPT THE RECORD:

I. ITINERARY FIELD
- A. Flight Segment - This consists of airline, flight #, class of service, date and month, origin, destination, action taken, # of seats, departure time, and arrival time.
- B. Auxiliary Services - This consists of hotel, car, tour, limo, etc. requests. Required information to enter it is the auxiliary code (htl,car,tur,lim,sur), airline, action taken, city, date and month.

II. NAME FIELD
- A. N:1 Maxwell/J = one surname
  N:1 Maxwell/J N:1 Roberts/T = more than one surname
- B. Cross-reference
- C. Name changes
- D. Infants

III. CONTACT FIELD
- A. P:CHIB/312 268-9540 x31/B/312 275-4830 - phone
- B. P:CHIA/Res/1221 N. Harlem Chicago Illinois 60647 -address

IV. TICKETING FIELD
- A. Ticketed
- B. Pta
- C. Revalidation
- D. Ticket by mail
- E. Ticket office will call
- F. Airport will call
- G. Teleticketing
- H. Other airline ticketing

V. GENERAL FACTS FIELD
Information which is valuable to us but does not need to be transmitted to the airport or ticket counter.

VI. SUPPLEMENTARY INFORMATION FIELD
Requests which require advance action or a reply.

VII. RECEIVED FIELD
Identifies the caller

— Schedule changes are handled with special action codes within the itinerary. (UN, WK, SC)

— To determine the path a certain flight travels enroute to its destination:
VITflt.#/dateandmonth example: VIT346/26Jan
The response will be cities the flight goes to at the left and times of departure and arrival at each city on the right.

— SPLIT & DIVIDE - A function to divide a party of 2 or more into separate records.
1) D1*3 -- Asking Apollo to give you only the first and third names out of the group of names.
2) D1¤2Kelly/E/Mstr T -- Asking Apollo to give you Mr and son out of the rest of the family.

FIGURE 2. *Page from a training manual depicting an example of information such a system might deal with.*

pulleys. There are some mechanisms which do the writing and erasing of characters on this belt; a reader puts his fingers on the belt on the platen - and here we go! A sensitive trigger under the platen starts the transport and a selector switch provides different modes of operation and finally there is a speed control for the operator to use. One can, of course, if one misses a character, move on with the belt a little, to spend a bit more time with each character; then, later on, one has to make that up by shifting one's hand gradually back upstream. In short, there is some buffering available in a dynamic display. The average rate is, however, adjusted to suit conditions by means of the speed control.

With such an output device, the problem becomes one of optimizing the man-machine interaction (cybernetics). In this matter, one needs to consider learning mechanisms of the blind. For example, blind people achieve quite satisfactory mobility, particularly in familiar surroundings.

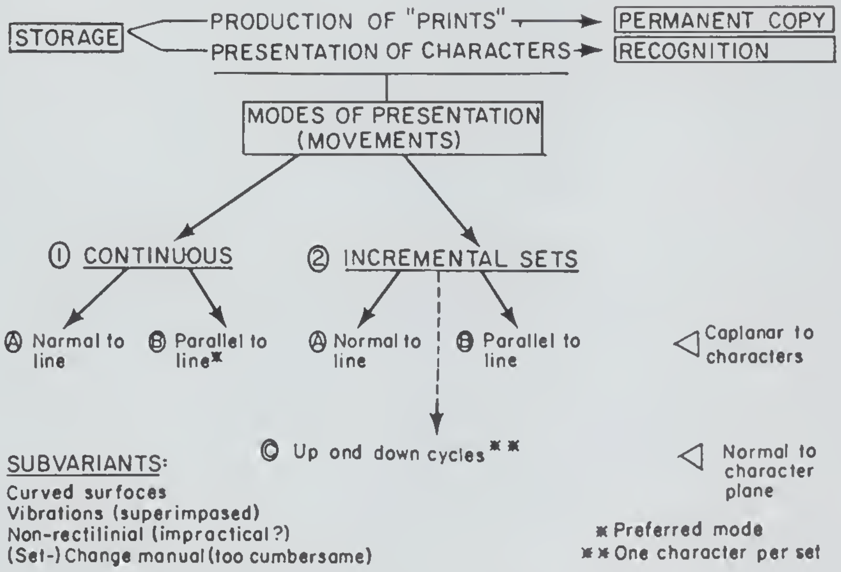
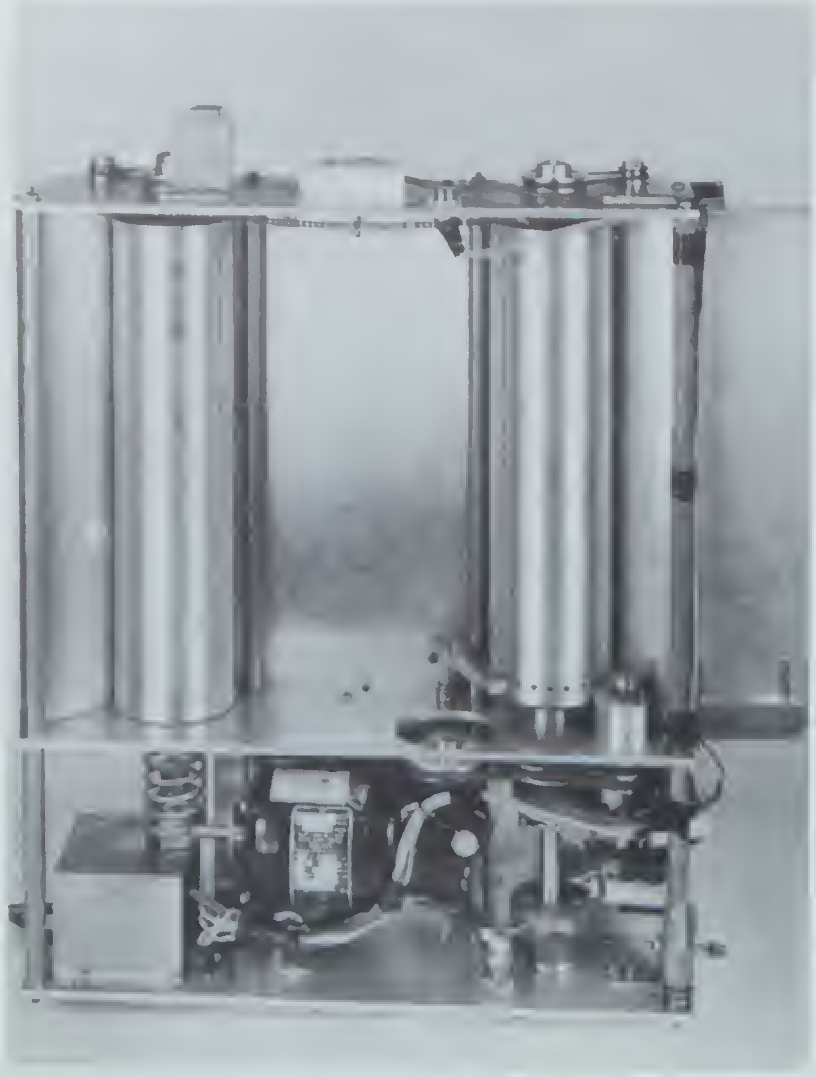


FIGURE 3. *Schematic of family of modes for character presentation.*



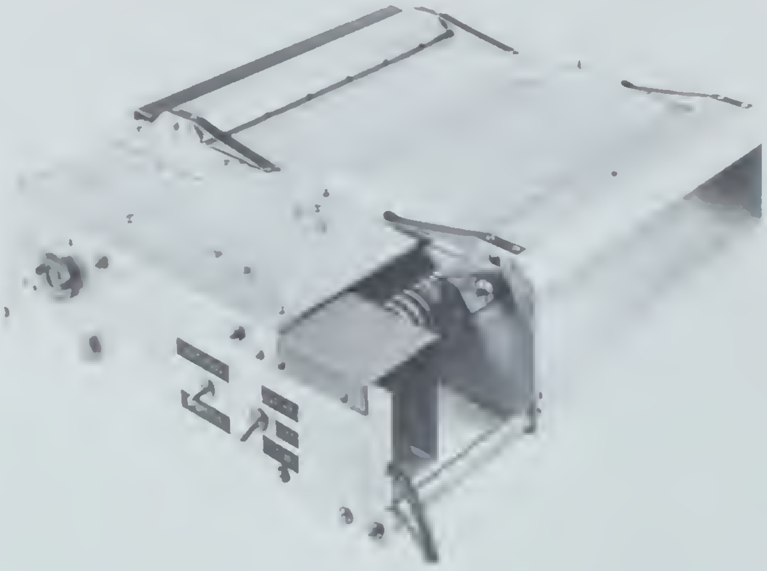


FIGURE 4. Testing device used in evaluation of modes.

Contrary to some seeing peoples' ideas, for instance, the number of paces between objects are not committed to memory, but they appear to develop, from a multiplicity of clues, a subconscious awareness of topography. It is this type of ability which must be counted on for the terminal design. A number of interesting questions arise, such as:

1. How general in nature or specific to a particular application (job function) should the terminal be?
2. What design features would minimize job training requirements?
3. What should be the physical placement of the output device relative to the keyboard to facilitate the input-output dialogue?
4. What "start", "stop" and/or "speed" control (knee, foot, etc.) should be provided for optimum utilization?
5. Should an audio indicator be provided to announce the arrival of information from the computer?
6. Are normal video terminal cursor selection controls (LEFT-RIGHT-UP-DOWN-CARRIAGE RETURN-HOME*, etc.) sufficient for braille information selectivity? (e.g., column scan).

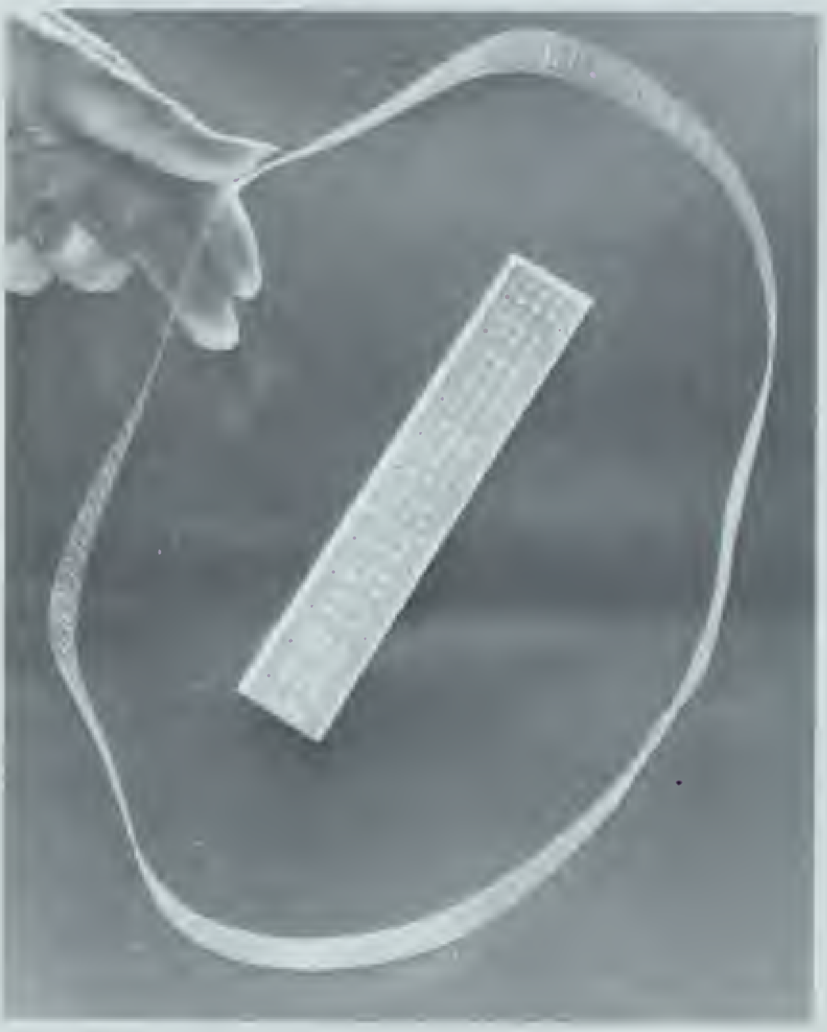


FIGURE 5. Argonne Braille Belt with cancellable "dots" arranged in standard braille cells.

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*The normal cursor "HOME" position refers to the first character position (character "1" on line "1") on the video "page".

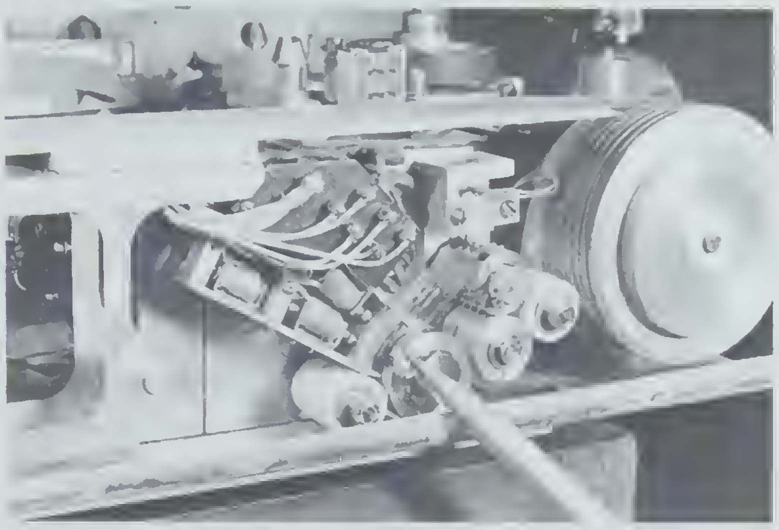

FIGURE 6. *Erasing and resetting mechanisms of the Argonne Braille Machine.*

Answers to these and other questions must be studied. It is anticipated that this can be done without great difficulty.

A necessary objective in providing a device of the kind discussed for the blind is that it would require no modification to the host system beyond that normally required for the variety of video terminals being marketed. This requirement does not appear to present a major restriction for several reasons. First, memory is ordinarily provided at the terminal from which the video display is refreshed. The same (type of) memory will provide the braille output as requested by the operator. This means that additional logic will be provided in the braille terminal for alphanumeric to braille character conversion, as well as escape character generation (not a formidable task in Braille I). Second, both the memory and the keyboard will appear electrically identical to a standard terminal unit.

A terminal of the type described has applications in many areas where computer-based data systems are currently in use.

At this time, at least four areas of application of the device are apparent:

1. Clerical positions in such areas as:
   - a. Airline reservation
   - b. Order taking and inventory control
   - c. Credit file searching
   - d. Service representation
2. Managerial positions involving decisions made on the basis of computer-based files.
3. Professional positions, primarily in technical areas, ranging from computer programming to computer work in science; other areas of science and engineering may also provide opportunities for utilization.
4. Computer Aided Instruction (CAI). In this area, the blind could be on a par with the sighted, and no distinction in the presentation of materials need be made.

FIGURE 7. *Braille machine being used.*

As an example of how such a braille terminal might be used, consider an application with an airline reservation clerk. (Figure 1 is a block diagram of how the braille terminal would be connected in place of a standard terminal). Figure 2 shows a facsimile of a list of instructions for operations performed while interacting with a prospective customer (passenger) and a computer. During this interaction, the clerk communicates with the prospective customer via telephone, and communicates with the computer via keyboard and terminal display. The computer, which has schedules, availability, and other supportive information stored in its memory, is programmed to selectively provide such parts of the available information as are specified by the operator.

The clerk, whether handicapped or not, would on request give the caller information on schedules, availability of reservations, known delays for particular flights, connections, ticket pricing, etc., all of which can be obtained from the computer in a programmed fashion. For instance, the operator may ask for the "first nonstop flight after 11 a.m. from Chicago to Boston with seats available." While interacting with the customer, the clerk can make preliminary entries in the computer memory (taking notes, as it were). After the customer has decided on a booking, the clerk will confirm (from notes retrieved from the computer on his display) the details of the reservation to be made. He then enters the corresponding booking (the passenger record) in the computer by means of his keyboard and erases the notes from the computer memory, thereby completing the clerk's function.

In this kind of application, the information sent to and received from the computer is highly organized and coded; thus, the operator need not sift through a mass of data to obtain the answer to his inquiry and the number of characters that need to be displayed and read is small. Consider for an example the following possible computer response for the above request: (First nonstop flight after 11 a.m. from Chicago to Boston).

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11:00a     2:05p     UA     699     F/Y   D10   L    0
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To request this output line and accompanying lines, the operators must first know the code for both departure and destination to type in as entering arguments (e.g., ORD is Chicago O'Hare Airport). This does not pose a serious problem to a blind operator any more than to a nonhandicapped person; as a matter of fact, he may be expected to be especially well prepared for responding to clues to information (which is almost synonymous with "decoding") by his usual daily chores. This would seem generally true because much of the information provided for in an environment designed for the seeing must be inferred indirectly ("decoded") by the blind. Furthermore, specifically the usage of Grade II braille would appear to be conditioning beneficial in the outlined work situation: the Grade II code, relying on context of word and sentence structure and even on conceptual content of the message transmitted in the rules of usage, cannot but develop agility in dealing with abstract "languages".

To envision corresponding procedures in some detail, consider again an airline reservation desk; parts of an inquiry may concern questions such as, "Is lunch served on the flight in question aboard a DC-10 aircraft?", etc. This type of knowledge is acquired through normal operator training. Remember, in the previous example, that perhaps ten corresponding lines would be stored in the terminal memory; thus, the operator could specify which part of this information he wants to appear on the braille display. The operator could begin by hitting the "Home" key which sets readout to the beginning of the first line, hit the "Right" key to read across to the arrival time of 2:05 p.m., hit the "Down" key to column scan the arrival times, hit the "Carriage Return" key to start at the beginning of the desired line, and then hit "Right" again to read that line. The formatting for the above hypothetical operation should, of course, be carefully chosen, e.g., should "Right" and "Left" initiate continuous readout or the readout of a known group of characters.

While many answers must yet be determined and operator techniques developed, the authors feel that a braille computer terminal as described here could well provide employment and educational opportunities for the blind which has as yet been virtually untouched. The design of such a system does not seem to present insurmountable difficulties.

The authors acknowledge that Mr. Robert Humbert of the American Association of Workers for the Blind in Oakland, California has first alerted them to the potential of this application of the Argonne Braille Machine.

United Airlines has kindly provided us with valuable details of the environment and mode of operation of airlines reservation facilities.

Dr. Lois Leffler and David Jacobsohn (of the Applied Mathematics Division of ANL) participated in a preliminary study of the subject.